

ATTACHMENT 10

**DAGUNA - *SURVEYS FOR PROTECTED FRESHWATER MUSSELS AT THE PROPOSED GREEN RIDGE
RECYCLING AND DISPOSAL FACILITY IN CUMBERLAND COUNTY, VIRGINIA***

REVISED MARCH 27, 2021

REVISED FINAL REPORT

Surveys for Protected Freshwater Mussels at the Proposed Green Ridge Recycling and Disposal Facility in Cumberland County, VA

by



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EXECUTIVE SUMMARY

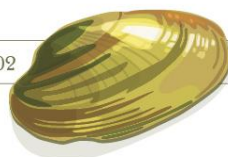
The proposed Green Ridge Recycling and Disposal Facility would impact tributaries to the James River. Streams in the James River basin are inhabited by the federally endangered James Spinemussel (*Parvaspina*=*Pleurobema collina*), the federally threatened Yellow Lance (*Elliptio lanceolata*), the state-threatened Green Floater (*Lasmigona subviridis*), and the state-threatened and now candidate for federal listing, Atlantic Pigtoe (*Fusconaia masoni*). The nearest occurrence of a federally listed mussel species was in neighboring Buckingham County. In May 2019 biologists with Daguna Consulting, LLC surveyed at least 19,000 m² of suitable habitat in Muddy Creek and 5,400 m² in Maple Swamp Creek. Several other feeding tributaries were assessed for suitability. Surveys and assessments were precisely georeferenced and habitats qualitatively documented. Live mussels and habitat were photographed. Efforts were sufficient to detect all mussel species (including James Spinemussel, Yellow Lance, Atlantic Pigtoe and Green Floater) present at densities ≥ 0.01 m⁻².

Muddy Creek supports a low-density mussel assemblage comprised of three common species: Eastern Ellipito (*E. complanata*), Northern Lance (*E. fisheriana*) and Eastern Floater (*Pyganodon cataracta*). No mussels were detected in Maple Swamp Creek. Small tributaries feeding Muddy Creek and Maple Swamp Creek were too small to support freshwater mussels. No federally listed or state-protected freshwater mussels were located within or directly downstream of the proposed Green Ridge Recycling and Disposal Facility.

INTRODUCTION

The proposed Green Ridge Recycling and Disposal Facility is planned for rural Cumberland County, Virginia. Preliminary review of the property indicated that streams potentially containing freshwater mussels may be present. Therefore, the project developer requested a survey for the imperiled freshwater mussels to better understand any potential impact. Nearby perennial streams include Muddy Creek and Maple Swamp Creek. These perennial streams border and, in some places, flow through the Green Ridge property (Figure 1). Many unnamed tributaries to these streams drain the property.

The James River Basin is inhabited by the federally endangered James Spinemussel (*Pleurobema collina*), the federally threatened Yellow Lance (*Elliptio lanceolata*), the state-threatened Green Floater (*Lasmigona subviridis*), and the state-threatened Atlantic Pigtoe (*Fusconaia masoni*). The state-listed Green Floater is known from the James River upstream and downstream of the Muddy Creek confluence (The Catena Group 2010, Chazal et al. 2012). Relic shell material of the Atlantic Pigtoe was recently detected in the Powhatan County reach of the James River by Chazal et al. (2012). The James Spinemussel is known from nearby Rock Island Creek (~ 40 km to the northwest, Chazal et al. 2012). Small populations of Yellow Lance persist in the headwaters of the James River, far to the west. Ostby (2007) detected a significant population of a common mussel species (Eastern Elliptio, *Elliptio complanata*) in a small unnamed stream in Powhatan County (~20 km to the east). That small unnamed stream was comparable to the perennial streams on the Green Ridge site. Chazal et al. (2012) conducted 2



surveys of Davis Creek, a tributary to Muddy Creek entering downstream of the Green Ridge site. They identified suitable habitat but detected no native mussels in those surveys.

On May 25 and 26, 2019, biologists Brett Ostby and Braven Beaty of Daguna Consulting, LLC visited the Green Ridge property to assess potential mussel habitat in streams and conduct surveys for freshwater mussels where necessary. Surveys were conducted to meet the requirements of “Abbreviated Surveys” as defined in “Freshwater Mussel Guidelines for Virginia (USFWS and VDGIF 2013)”. Most efforts focused on Muddy Creek and Maple Swamp Creek.

METHODS

Stream Assessment

We either visited streams by hiking through the site or assessed streams as they entered either Muddy Creek or Maple Swamp Creek. Assessments determined whether sufficient flow and suitable substrate were present to support freshwater mussels. We also assessed overall stream conditions. In some streams with sufficient flow, we searched for mussels.

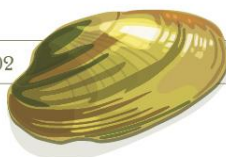
Stream Surveys

The perennial streams (Muddy Creek and Maple Swamp Creek) were surveyed for mussels to qualitatively assess species composition, abundance, and the possible presence of protected species. Surveys were designed to detect all mussel species present in Virginia. In accordance with the published Virginia freshwater mussel survey guidelines, we searched reaches of stream extending from 400 downstream to 100 m upstream of proposed impacts. Because most habitats were shallow (<0.5 m), we used viewscopes and unaided visual inspection. In some areas tactile searches were employed. All stream reaches were surveyed unless the habitat was deemed “unsuitable” for mussels based on the site visit. The “unsuitability” of any stream reach(es) as habitat for mussels was fully documented. We searched stream banks and exposed shoals for mussel shells to obtain a complete list of species at the site. Surveys were conducted when water level and clarity were suitable to locate shells and live individuals with ease. Sufficient effort was expended to visually inspect a sufficient amount of suitable habitat so that we could state with reasonable confidence that endangered and/or threatened species did or did not occur in the reach sampled. Representative specimens of each species detected were photographed. Geographical Information System (GIS) programs were used to georeference survey boundaries, location of protected species, and location of other pertinent features.

RESULTS

Weather and Stream Conditions

Skies were clear on both May 25th and May 26th. Air temperature reached a high of 29 °C (85 °F) on May 25th and 32 °C (90 °F) on May 26th. Flows were assumed to be near median in Muddy Creek and Maple Swamp Creek based on information from nearby gages, including USGS 02036500 on Fine Creek at Fine Creek Mills, VA and USGS 02039500 on the Appomattox River at Farmville, VA. Little to no rain had fallen in the area over the preceding week. Water clarity in Muddy Creek was limited due to tannins and turbidity from an unknown



source. In general, the streambed was clearly visible in laminar flows less than 0.4 m depth. Water temperature in Muddy Creek was 22 °C (76 °F) when surveyed on May 25th. Maple Swamp Creek had no evidence of tannins and was considerably clearer, with all streambed habitats visible from the water surface in laminar flow. Water in Maple Swamp Creek was 18°C (64 °F) during the May 26th survey.

Muddy Creek Habitat and Species Observations

We surveyed Muddy Creek from the abandoned Miller Lane bridge (37.584320, -78.106711) to upstream of the Pine Grove culvert crossing (37.567270, -78.138347), with the exception of a 100 m reach directly downstream of the Pine Grove crossing (Figure 2). The total surveyed reach was approximately 3,800 m. Muddy Creek flowed through a corridor of mature bottomland forests, with extensive marshes in the 1000 m reach upstream of the abandoned bridge (Figure 3). Its average bankfull width was 7 m with wetted width usually 5-6 m. Bankfull height was 1 to 1.5 m throughout, with sand banks forming a natural dike between the channel and marsh areas. In forested areas, banks were steep but stable and usually vegetated (Figure 4).

Instream habitat in Muddy Creek was 95% run habitat with a sand streambed (see Figure 3). The sand streambed ranged from firm to soft. All instream habitat structure in the lower 3,400 m of the surveyed reach was formed by large woody debris. Approximately 5% of the habitat was pool. Exposed bedrock, boulders, cobble and gravel were only observed starting 300 m downstream of the Pine Grove crossing. From 400 m downstream to 200 m upstream of the Pine Grove crossing, a few riffles were noted (Figure 5). Overall the streambed was 99% sand, with some patches being unstable and soft. Maximum water depth was 1.25 m with most habitats less than 0.4 m deep.

In a 9 person-hour effort, we detected 12 live Eastern Ellipito (*E. complanata*), 5 live Northern Lance (*E. fisheriana*) and 1 live Eastern Floater (*Pyganodon cataracta*) in the main channel of Muddy Creek. Figures 6-8 are photographs of example specimens. We detected live mussels only from the start point to approximately 1000 m upstream. We observed recent shell material on exposed banks nearer the Pine Grove crossing, but no live specimens were detected in the vicinity. Non-native Asian Clams (*Corbicula fluminea*) were present throughout the stream but not common. There was little habitat for aquatic insects except near the Pine Grove crossing where we observed a few mayfly larvae under cobbles. We also observed some water scorpions (*Ranatra*) in large woody debris closer to the survey start point. We observed cyprinids, mostly dace, and centrarchids. Several centrarchid nests were noted near the survey start point. Three frog species were abundant in Muddy Creek and its associated wetlands including Green Frogs, Cricket Frogs and Leopard Frogs. Tadpole of American Toads and calls of Grey Treefrogs were also noted.

We noted several tributaries entering Muddy Creek (marked as Trib 1-3 and 5-6 in Figure 2 and geo-referenced as Trib 1-6 in Table 1) but none appeared suitable for freshwater mussels, being either too small or unstable (Figures 9-14, see Table 1 for locations). We extensively searched a tributary flowing from the south which eventually dissipated into a marsh but found no evidence



of mussels (Trib 1, see Figures 9 and 10). The largest tributary flowing through the Green Ridge property into Muddy Creek from the northwest had a significantly incised channel clogged by sand with little flow (Trib 3, 37.5744, -78.12536, see Figure 12). Upstream of the Pine Grove Road crossing, we assessed and surveyed an unnamed tributary draining from the south. This stream showed evidence of recent catastrophic disturbance, with a newly incised channel cut into clay banks (Figure 14). There was also a copious amount of gravel, likely originating from Brown Road, in the stream bed (see Figure 5). Further survey of this stream was not warranted. Other tributaries flowing off the Green Ridge site into the surveyed reach of Muddy Creek as marked on the topographic map by dotted blue lines (see Figure 2) were not detected during the survey of Muddy Creek because they were likely dry on May 25th.

Maple Swamp Creek Habitat and Species Observations

At the survey start point (37.55975, -78.10566), Maple Swamp Creek flowed along a marsh on its left ascending side and a mature forest on the other (Figure 15 and 16). This reach had low banks (<0.5 m). It was exclusively run habitat with a sand stream bed. Some patches of sand were extremely soft. Large woody debris was common. Bankfull width was 3-4 m and mostly wetted. Water depth was usually less than 0.3 m.

Moving from downstream to upstream the character of Maple Swamp Creek gradually changed. Further upstream, this stream flowed through a mature forested corridor with higher banks. Upstream of the unnamed tributary labeled Trib 7, riffles and larger streambed particles became more common. For approximately the upstream 600 m of the surveyed reach, bankfull height was usually 1 to 1.5 m, reaching a maximum of 2 m. For the upstream 600 m of the surveyed reach habitat was 75% run, 10% riffle and 5% pool (Figure 17). While most of the streambed remained sand (75%), boulder, cobble and gravel were more common. Some habitats had an exposed bedrock streambed.

In a 5 person-hour effort, we surveyed an approximately 1,800 m reach, detecting no evidence of native mussels. No Asian Clams (*C. fluminea*) were detected either. Fish were more common in Maple Swamp Creek than in Muddy Creek, with dace, central stone rollers, and darters observed. Aquatic insects were more frequently encountered in Maple Swamp Creek than in Muddy Creek, including mayfly larvae, whirligig beetles, caddis fly larvae and water pennies. Several frog species were abundant in Maple Swamp Creek and its associated wetlands including Green Frogs, Cricket Frogs and Leopard Frogs. Calls of Grey Treefrogs were also noted.

Two apparently perennial tributaries (Trib 7 and 8 on Figure 15) were assessed. No evidence of mussels was detected though suitable habitat and habitat complexity were noted near Maple Swamp Creek in both cases (Figures 18 and 19).

CONCLUSION

Muddy Creek supports a low-density mussel assemblage comprised of three common species. We found no evidence to suggest additional species inhabited the surveyed reach. None of the Muddy Creek tributaries draining the Green Ridge property appeared to provide suitable habitat



for native mussels. We found no evidence to suggest Maple Swamp Creek or its tributaries were inhabited by native mussels. Disturbances to any stream flowing off the Green Ridge property might impact native mussels living downstream in Muddy Creek. Maple Swamp Creek is also a tributary to Muddy Creek.

An adequate amount of habitat was searched to detect extremely low-density populations of protected species. Using a sampling equation from Smith (2006), we calculated post hoc detection probabilities based on total area searched and assumed detection of an individual mussel when present (or search efficacy, Table 2). We surveyed at least 19,000 m² of habitat in Muddy Creek and 5,400 m² in Maple Swamp Creek. Generally, detection of an individual mussel is 0.2 on a scale from 0 to 1, where “0” means an individual was present but not detected and “1” means an individual was detected. An individual detection rate of 0.1 was more appropriate for Muddy Creek due to tannins and turbidity, whereas 0.2 was appropriate for Maple Swamp Creek. We had an extremely high probability (>0.99) to detect mussels present at 0.01 m⁻² in both Maple Swamp Creek and Muddy Creek.

Densities in Muddy Creek were so low that it would require large areas be surveyed to detect existing populations, so it should be no surprise that Department of Conservation and Recreation, Division of Natural Heritage surveys conducted by Chazal et al (2012) failed to detect mussels in the Muddy Creek drainage.

LITERATURE CITED

- Ostby, B. J. K. 2007. Stream Survey for Protected Mussels in Unnamed Tributaries to Fine Creek, Powhatan County, Virginia. Report for Balzer and Associates, Powhatan, VA. 13 pp.
- Chazal, A. C., B. T. Watson and B. C. Flower. 2012. Results of James Spiny mussel Surveys in the James River and Tributaries of Central and Eastern Virginia. Report for Virginia Department of Game and Inland Fisheries, Richmond, VA. 222 pp.
- Smith, D. R. 2006. Survey design for detecting rare freshwater mussels. *Journal of the North American Benthological Society* 25(3): 701-711.
- The Catena Group. 2010. Freshwater Mussel Survey Report for Proposed Water Intake, James River, Powhatan Co, VA. Report for Malcom Pirnie, Inc. Newport News, VA. 15 pp.
- U. S. Fish and Wildlife Service and Virginia Department of Game and Inland Fisheries. 2013. Freshwater Mussel Guidelines for Virginia. Gloucester, VA. 9 pp.



Table 1. Latitude and longitude markers (WGS84) for mussel surveys and assessments.

Label	Latitude	Longitude	Figure
Assessment Trib 1 upstream	37.57729	-78.11288	
Assessment Trib 1 and photo	37.57812	-78.11368	9
Assessment Trib 1 downstream and photo	37.58120	-78.11529	10
Muddy Creek survey start	37.58423	-78.10672	
Assessment Trib 2 and photo	37.57520	-78.12201	11
Assessment Trib 3 and photo	37.57440	-78.12536	12
Larger substrate and exposed bed upstream	37.57089	-78.12895	
Assessment Trib 4 and first riffle	37.57006	-78.12954	
Shells on exposed bar	37.56992	-78.13188	
Assessment Trib 5 and photo	37.56804	-78.13322	13
Road gravel noted in streambed	37.56740	-78.13779	5
Upstream Assessment Trib 6 and photo	37.56806	-78.13294	14
Muddy Creek survey end	37.56729	-78.13835	
Upstream Assessment Trib 7	37.55895	-78.11561	
Assessment Trib 7 and photo	37.55569	-78.11260	17
Maple Swamp Creek survey start	37.55971	-78.10574	15
Assessment Trib 8 and photo	37.55217	-78.11458	18
Upstream Assessment Trib 8	37.55216	-78.11551	
Maple Swamp Creek survey end	37.54780	-78.11513	



Table 2. Probability of detecting a species (p) using Smith (2006) equation, $p = 1 - e^{-\beta\alpha\mu}$, given search efficacy (β), actual area covered in a survey (α), and a theoretical density (μ). We also present a theoretical population size for a survey reach for a given density (0.01 or 0.005 individuals per meter square). For example, if we were only able to detect 1 in 10 *L. subviridis* present in Muddy Creek and there were only 94 in the entire surveyed reach, we had a 0.9913 probability to detect at least a single individual.

Stream	p Probability of population detection	β Probability of Individual Detection	α Area Visually Searched	μ Population Density	Population Size in Survey Reach
Muddy Creek	0.9999	0.05	19000	0.01	190
	1.0000	0.1	19000	0.01	190
	0.9913	0.05	19000	0.005	95
	0.9999	0.1	19000	0.005	95
Maple Swamp Creek	1.0000	0.2	5400	0.01	54
	0.9955	0.1	5400	0.01	54
	0.9328	0.05	5400	0.01	54
	0.9955	0.2	5400	0.005	27
	0.9328	0.1	5400	0.005	27
	0.7408	0.05	5400	0.005	27

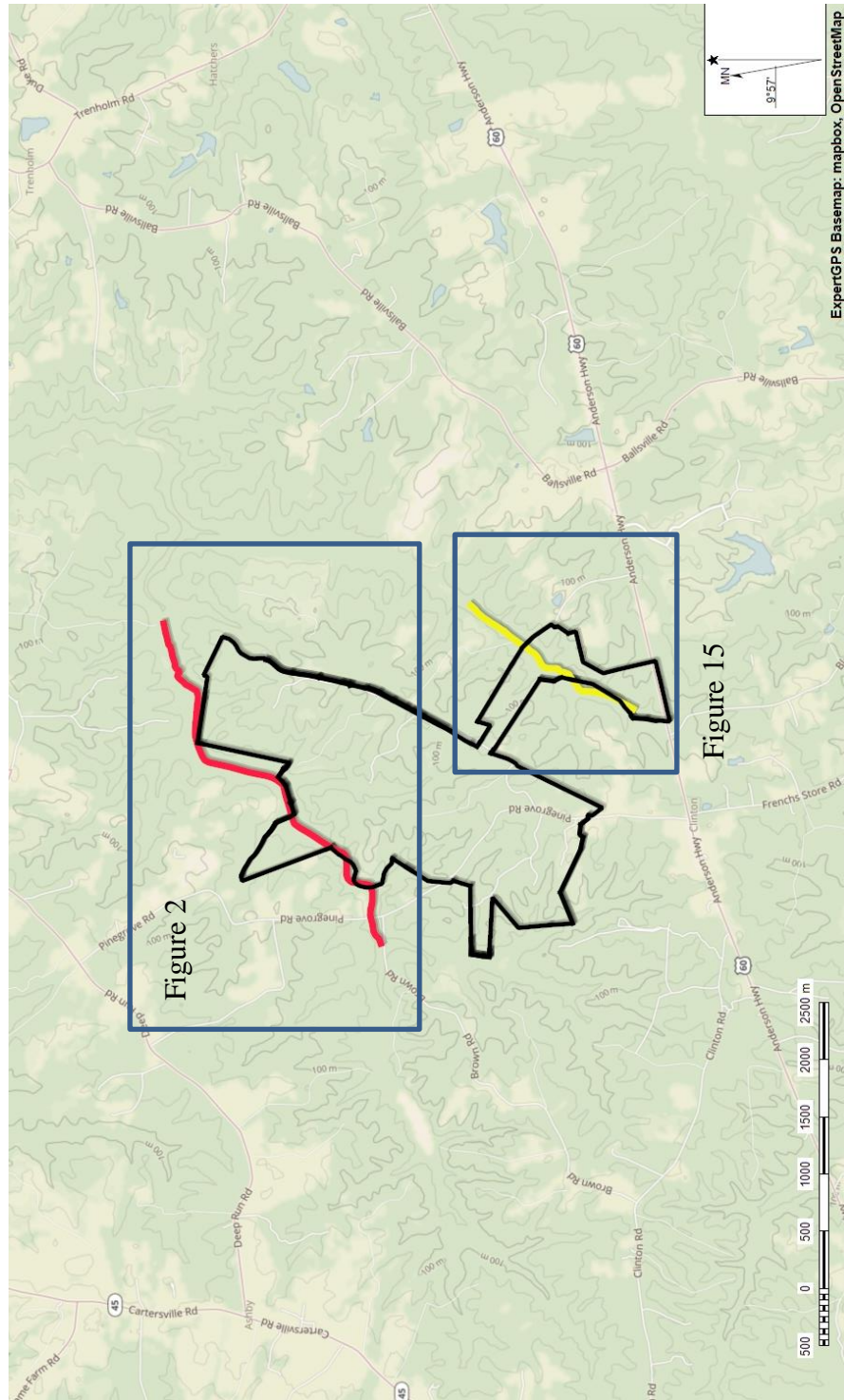


Figure 1. Area road map illustrating the reaches of Muddy Creek (red) and Maple Swamp Creek (yellow) that were surveyed for freshwater mussels. Property boundaries are marked in black.

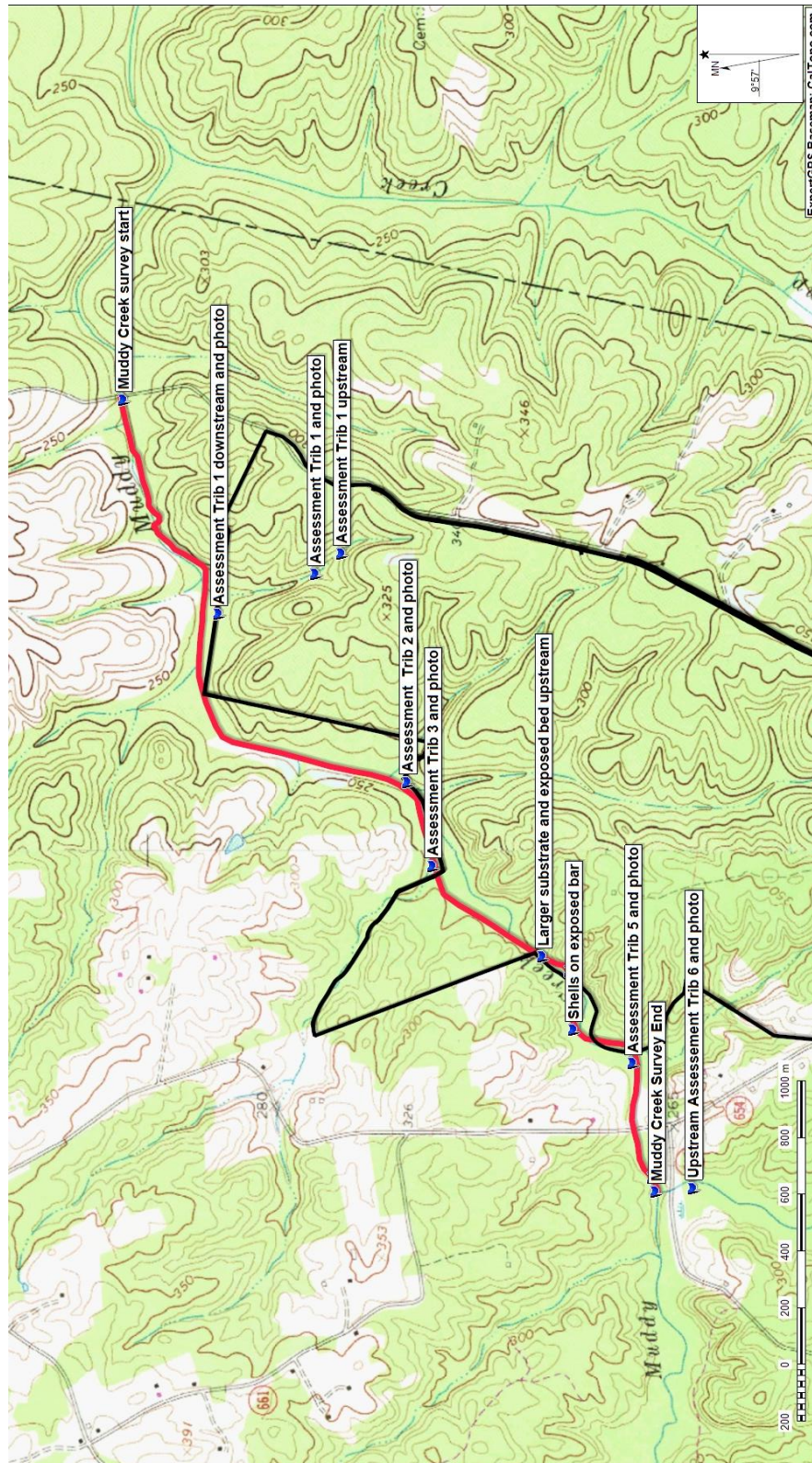


Figure 2. Topographic map illustrating survey reach of Muddy Creek (red) and its tributaries that were assessed. Property boundaries are marked in black. Tributary 4 was not marked here due to label overlap. All assessment are geo-referenced in Table 1.



Figure 3. Marsh bordering Muddy Creek near the survey start point. The most extensive marsh was present along the right ascending side.



Figure 4. Typical run habitat in Muddy Creek flowing through the forested corridor.

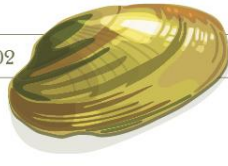


Figure 5. Muddy Creek upstream of Pine Grove crossing with gravel bar. Bar material appears to have originated from a gravel road and did not resemble stream bed material observed elsewhere in Muddy Creek or its tributaries.



Figure 6. The Eastern Elliptio (*E. complanata*) was the most frequently encountered species. Most were greater than 90 mm, with ages approximately 10 years or greater.

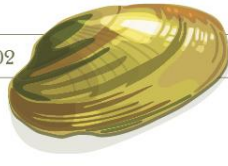


Figure 7. Northern Lance (*E. fisheriana*) were found in clay banks. Shell material of specimens as young as 3 years old were detected just downstream of the Pine Grove stream crossing on exposed bars.



Figure 8. We observed only a single specimen of Eastern Floater (*P. cataracta*) in Muddy Creek. It was 4 years old.

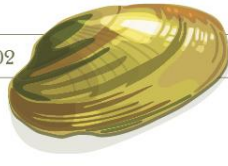


Figure 9. Stream feeding Muddy Creek from the south (Trib 1) was deeply incised in some locations. It was likely too small to support native mussels but did harbor dace.



Figure 10. Forested marsh near the Muddy Creek channel where the unnamed tributary channel (Trib 1) pictured in Figure 9 dissipated.



Figure 11. A beaver dam blocked this small tributary draining the Green Ridge site from the south (37.57520, -78.12201). This stream was too small to support freshwater mussels, so no further survey was warranted.

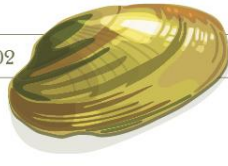


Figure 12. Unnamed tributary feeding Muddy Creek from the northwest had little flow and contributed large amounts of sand (37.5744, -78.12536). This stream drains the Green Ridge site and was not surveyed. Flow was only a few mm deep and filled less than half the channel, suggesting it may be ephemeral.



Figure 13. We followed this unnamed tributary as we exited Muddy Creek and made several checks (37.56804, -78.13322). Like other feeding tributaries it was too small to support mussels.



Figure 14. A recently incised channel within an older channel upstream of the new Brown Road crossing. This stream recently suffered a catastrophic event forming a new and deeper channel.

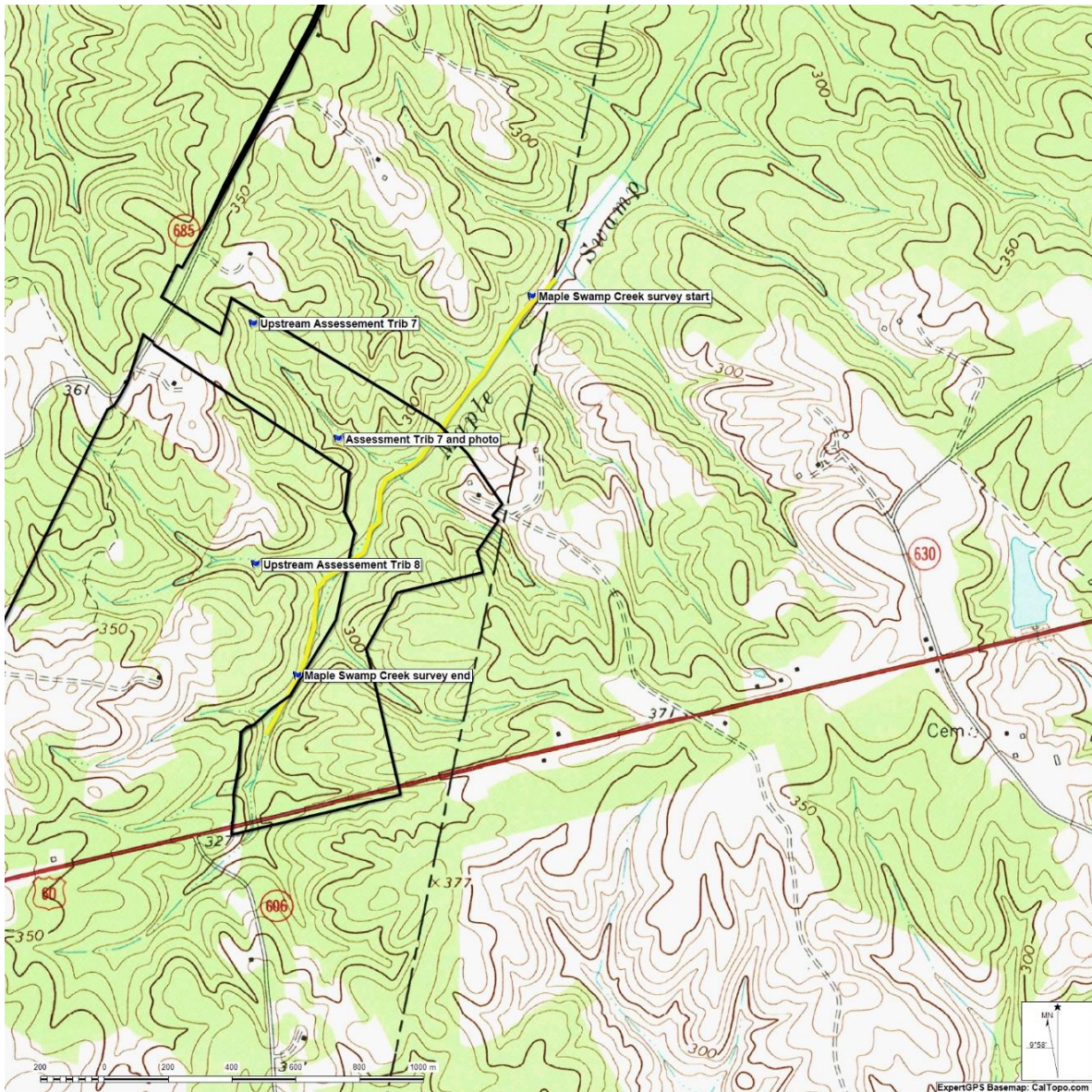


Figure 15. Topographic map illustrating survey reach of Maple Swamp Creek (yellow) and its tributaries that were assessed. Property boundaries are marked in black.

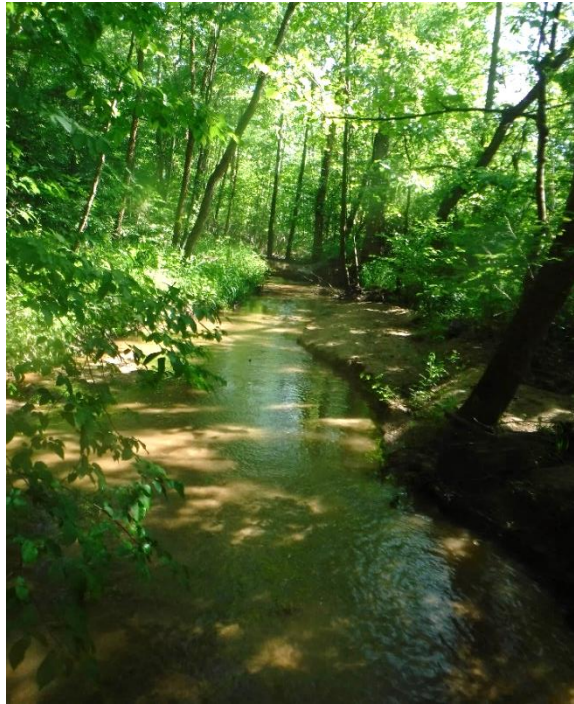


Figure 16. Run habitat with a sand streambed in Maple Swamp Creek near survey start.

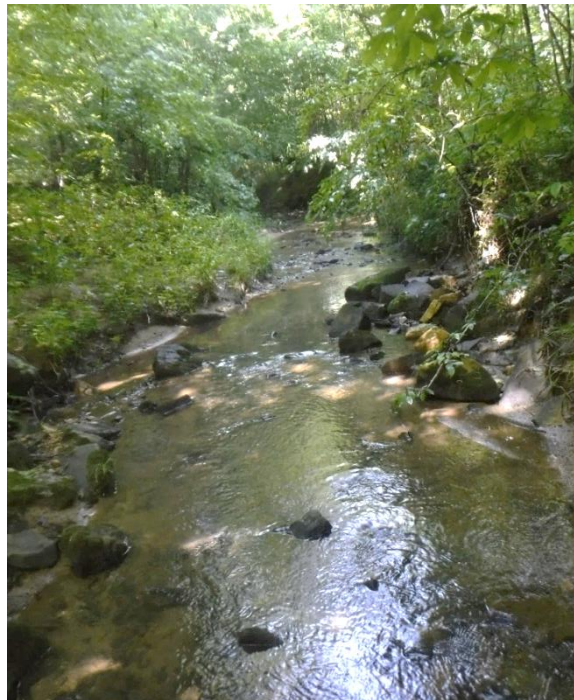


Figure 17. More complex meandering instream habitat farther upstream in Maple Swamp Creek. Boulders and cobble in the streambed here were absent downstream. We observed more fish, including darters in this habitat.

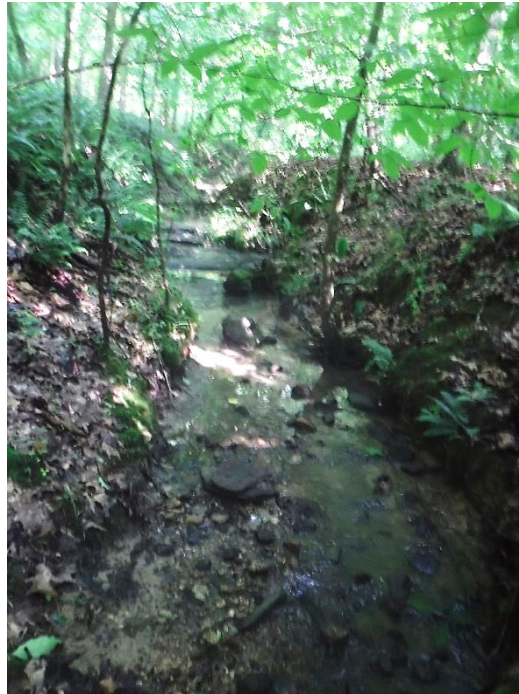


Figure 18. While hiking in from Miller Road, we searched approximately 200 m of a tributary feeding Maple Swamp Creek, finding suitable habitat but failing to detect any evidence of mussels (37.55569, -78.11260).



Figure 19. We searched an approximately 200 m reach of a small tributary feeding Maple Swamp Creek from its mouth upstream finding no evidence of mussels (37.5521, -78.11458).



Survey Record #1

Site #: DAGUNA05252019.1

Stream: Muddy Creek

County: Cumberland

Description: Surveyed 3,800 m reach of main channel and assessed several feeding tributaries

Drainage: James

USGS Quadrangle Map: Whiteville/Trenholm

Projection: WGS 84

Survey Start: 37.58423, -78.10672

Survey End: 37.56729, -78.13835

Survey Date: 5/25/2019 and 5/26/2019

Survey Effort: 9 person-hours

Personnel: B. J. K. Ostby, B. B. Beaty

Mollusks Observed:

12 Live *Elliptio complanta*

5 Live *E. fisheriana*

1 Live *Pyganodon cataracta*

Live *Corbicula fluminea* (uncommon)



Survey Record #2

Site #: DAGUNA05262019.1

Stream: Maple Swamp Creek

County: Cumberland

Description: Surveyed 1,800 m of main channel and assessed 2 feeding tributaries

Drainage: James

USGS Quadrangle Map: Trenholm

Projection: WGS 84

Survey Start: 37.55971, -78.10574

Survey End: 37.547796, -78.11513

Survey Date: 5/26/2019

Survey Effort: 5 person-hours

Personnel: B. J. K. Ostby, B. B. Beaty

Mollusks Observed:

None